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ABSTRACT

The middle school years have been identified as a crucial period in the development of students' scientific understanding skills and attitudes. Likewise, the preparation of middle school science teachers is considered to be of critical importance. This paper focuses on current conditions and essential needs related to science education at the middle school level. A listing is provided of the variables that are believed to contribute to the problematic situation at the middle school level. Topics addressed include: (1) the middle school (highlighting its historical development and organizational patterns); (2) middle school students (describing the characteristics and needs of this age group); (3) characteristics of middle school teachers (noting desirable competencies and personal characteristics); (4) some variables that compound the staffing problem (using Ohio as an illustration of certification concerns); (5) role of professional organizations (discussing standards and guidelines for teacher preparation programs); (6) preservice preparation (focusing on problems and possible approaches); and (7) inservice education (reviewing needs and priorities). A list of 23 references are included in the bibliography. (ML)

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THE PREPARATION OF TEACHERS FOR MIDDLE SCHOOL SCIENCE

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THE PREPARATION OF TEACHERS FOR MIDDLE SCHOOL SCIENCE

Introduction and Background

In 1983 numerous reports were issued containing information critical of American education. These reports were focused on secondary education, for the most part. American students' lack of achievement was identified and compared to the achievement of past generations as well as to the students' peers in other countries. The need to improve education, particularly in science, is not confined to the senior high school. It extends downward to the lower grades.

A particularly crucial period is that of the middle school years. Research has shown that positive attitudes toward science begin to diminish during the middle school years. Much of the socially relevant science information that middle school students report to possess appears to be related to topics given wide coverage in the media (Hueftle, Rakow and Welch, 1983).

The need to improve the preparation of middle school science teachers is a crucial one. Because of the rapid growth of technology and a related emphasis on problem solving, it is important that middle school teachers are competent in science so they can provide their pupils with appropriate experiences. Science students' scores on decision-making items on National Assessment of Educational Progress tests have declined over the years. The middle school is a strategic location for the development of scientific information, skills, and attitudes. However, science education at the middle school level is problematic

because (1) many students are not motivated to learn science and have a negative attitude about science; (2) achievement levels for this age range are not at desired levels of accomplishment; (3) about half of the students take only one science course in high school unless more than one course is required for graduation; (4) goals and content that deal with science/society/technology relationships are frequently not included in the curriculum; (5) instructional strategies and materials are inconsistent with contemporary goals for science education (hands-on learning is not a priority) and with research on learning and instruction; (6) teachers lack content knowledge (particularly in the physical and earth sciences); (7) students frequently see "school science" as unrelated to everyday life; and (8) instruction is a routinized process with content presented through traditional, textbook-based expository methods.

Middle schools. The middle school is a fairly recent phenomenon in public school systems in the United States. Middle schools appear to have come into being for a variety of reasons. Ideally, middle schools were established for many of the same reasons that were given when the establishment of the junior high school was advocated. Basically, educators were seeking a different organization to more adequately meet the needs of the unique population the school served.

Middle schools began to develop in the 1950's because of dissatisfaction with the program and structure of the junior high school, combined with knowledge about (1) changes in maturation patterns of students, (2) problems of children moving from educational level to level, (3) new educational ideals, (4) developments in learning theory,

(5) innovations in educational methods and materials, and (6) changes in society (Malinka in Ochs, ed., 1981:3). Middle schools were considered to provide a type of organizational pattern more suitable (than that of the junior high school) for providing the most appropriate experiences for 10-14 year old pupils, based on knowledge of their developmental characteristics.

Theory and practice may differ, however. Not all middle schools were developed for the reasons just cited. Some were established to relieve overcrowding or to achieve racial balance. Others were established to avoid closing more senior high schools. (Fielder, 1978) Regardless of the reason for establishing middle schools, the trend toward the middle school pattern of organization appears to be a national one.

Middle school students. The middle school years reflect a period of life marked by rapid and drastic change and development. A major difficulty in dealing with these changes is the variable rate of growth among students resulting in greater differences than at any other stage of development. Because middle school teachers lack knowledge about these changes, the middle school has become the weakest link in the entire continuum of schooling. Early adolescents are characterized by numerous behaviors that have strong implications for science programs.

Middle school teachers need to understand that preadolescents and early adolescents (1) have a high degree of intellectual curiosity; (2) display great variety in cognitive maturation; (3) show a wide range of skills, interests, and abilities; (4) prefer active involvement to passive receptivity; (5) show concern and apprehension about personal changes and the future; (6) have a growing capability for use of com-

binatorial logic, second symbol systems, and introspection; (7) pose a dichotomized self (overt behaviors are often contradictory and extreme); (8) display a capacity to construct ideals enabling them to generate many alternatives that make decision making a problem; (9) show greater awareness of the rapidly changing world; (10) are experiencing an emerging intellectual capacity for formal thought processes needed for problem solving; (11) have emotional problems that stem from differences in student abilities that interfere with motivation and achievement; and (12) have not developed effective ways of constructing knowledge and, therefore, have formed many incorrect science concepts.

Characteristics of Middle School Teachers

In a chapter entitled "The Teacher in Middle School," Wiles and Bondi (1981) write, "The teacher we are looking for in the middle school is less the sage on the stage and more the guide on the side"(p.49). However, many educators do not perceive any problems relative to staffing middle schools; they consider that either elementary or secondary teachers can do the job. This assumption is questioned by those who believe that, because middle school students are a unique group, teachers for middle schools should be specially prepared to teach at this level.

Personal characteristics. Teachers for the middle school grades should honestly want to work with this age group. They need to be flexible, to possess enthusiasm (for teaching their subject to middle school pupils), to have a sense of humor as well as a large supply of patience. Middle school teachers need to be individuals to whom their pupils can relate, serving as a counselor as well as a teacher.

Teacher competencies. Several groups have developed lists of competencies considered desirable for middle school teachers. Some of those competencies are:

1) has the ability to organize the curriculum to facilitate the developmental tasks of pre- and early adolescents.
2) is able to organize his/her teaching according to an understanding of the physical, intellectual, and socio-economic development processes of middle school students.
3) understands and applies various theories of the teaching-learning process; analyzes the learning patterns of the individual students, prescribes for these and incorporates results in teaching.
4) is able to plan multidisciplinary lessons and/or units and teach them individually or with others.
5) can integrate appropriate media and concrete demonstrations into lessons.
6) plans and uses learning situations that promote independent learning by students; maximizes student choice and responsibility for follow-through.
7) is able to teach problem solving skills and to develop lessons that enable students to achieve these objectives.
8) is able to write behavioral objectives and to design lessons that enable students to achieve these objectives.
9) is able to teach the communication skills of reading, writing, and speaking in all subject areas.
10) commands knowledge of reading techniques to enable students to progress and improve their reading in the subject areas.
11) is skilled in diagnosis of reading problems and providing a remedial program in the regular classroom.
12) has a knowledge of careers and the ability to help students explore careers.
13) possesses skills necessary to effectively manage groups of students in activity settings.
14) provides frequent feedback to students on learning progress.
15) is able to function calmly in a high activity environment.
16) uses questioning techniques skillfully to achieve higher order thinking processes in students.
17) is able to maintain a balance between teacher-directed learning and student-directed learning.
18) when involved in curriculum and instruction, the teacher proceeds from a problem solving framework, involving the students in relevant inquiry.

19) is skilled in asking questions to encourage student thinking beyond the level of factual recall of information. (Wiles and Bondi, 1981:51-56)

The personal characteristics listed earlier in this section are variables that an individual either does, or does not, possess. Some may possibly be acquired if an individual works to develop that trait, e.g. patience or flexibility. The 19 competencies just listed, as well as others identified in Wiles and Bondi's book, should be acquired through a pre-service program that provides prospective teachers with the necessary experiences to develop these competencies.

However, preservice programs leading to middle school teaching certification are less common than are programs for elementary teachers or for secondary teachers. Typically, colleges and universities preparing teachers do not move toward a particular certification program unless state certification standards so mandate. Middle school administrators therefore must hire teachers who are not adequately prepared for their teaching assignment and are, consequently, in need of in-service education.

Some Variables that Compound the Staffing Problem

Some authors say that middle schools are ignored by teacher education institutions (Gatewood and Mills, 1975),which may be true. However, teacher educators respond that preservice programs for middle school teaching will not attract students until state certification standards mandate special certification to teach in middle schools. In their turn, personnel from state departments of education respond that it does not seem logical to require special middle school certification when courses and programs do not exist and there is a shortage of teachers for the middle schools (Gillan, 1978:18-19).

The State of Ohio provides an example of this dilemma. The results of a status study, completed in 1977 (Gillan, 1978), provide information about states having middle school certification. Ohio was described as one of the states. Certification procedures were described as "Teachers certified for middle schools upon recommendation of the Superintendent and upon completion of elementary course work." (Gillan, 1978:23) It might be inferred from this that, in Ohio, elementary teachers are already considered certified to teach in middle schools and teachers holding secondary certificates need to complete additional course work to obtain middle school certification. Currently, in Ohio, certification is for grades K-8 or 7-12. New certification standards will go into effect in July, 1987. When the new standards were in the discussion stage, middle school certification as separate from elementary and secondary was proposed, involving grades 5-8. The section relating to the middle school standards remained in committee while other standards were acted upon by the state legislature. Current speculation is that middle school certification will not be moved out of committee by next July. These standards had called for a prospective middle grades teacher to possess content in <u>one</u> of four subject matter areas: English language arts, 45 semester hours; mathematics, 20 semester hours; science, 45 semester hours; or social studies, 45 semester hours. Later this was revised to require the completion of 45 semester hours of subject matter content, divided between two content areas with a minimum of 20 semester hours in each area. Even if the middle school standards should find a sponsor who would remove this legislation from committee, there is no guarantee that future middle school teachers would have any subject matter competence in science beyond

those courses required as a part of the general education component for all undergraduate students.

The Role of Professional Organizations

Professional organizations and learned societies frequently issue position papers or develop guidelines related to the preparation of teachers within their discipline. The National Middle School Association has produced Professional Certification and Preparation for the Middle Level (1986) in an attempt to direct the education profession's attention to the lack of appropriate preparation and certification for middle school teachers. In the section of this document in which preservice preparation is discussed, these guidelines are stated:

> Middle grades teaching requires pre-service preparation essentially similar to that provided in most elementary or secondary education programs, but with certain special emphases.
>
> It should differ from elementary teacher preparation as follows:
>
> 1. Depth in one or two teaching fields, in addition to the diversified subject-matter preparation ordinarily required of elementary teachers.
> 2. Examination of the history, philosophy, and curriculum of the middle grades, both in and outside the school setting.
> 3. Special attention to
>   a. the characteristics and needs of the transescent.
>   b. the development of the skills of continued learning in and through instruction in such courses as reading, English, social studies, science, mathematics, foreign language, home economics, etc.
>   c. the guidance/advisory role of the teacher during transescence.
> 4. Methods and materials especially appropriate for middle grades students.
>
> Preparation for middle grades teaching should differ from secondary teacher preparation as follows:
>
> 1. Modest depth of preparation in two teaching fields, rather than specialization in one.
> 2. Examination of the history, philosophy, and curriculum of the middle grades.
> 3. Special attention to
>   a. the characteristics and needs of the transescent.
>   b. the development of skills of continued learning in and through instruction in such courses as English, social studies, science, mathematics, foreign language, home economics, etc.
>   c. the guidance/advisory role of the teacher during transescence.
>
> (1986:11)

The National Science Teachers Association has also provided some guidelines for the preparation of middle school teachers to teach science. Not only has NSTA issued a position statement relative to teacher certification, the organization has become affiliated with the National Council for the Accreditation of Teacher Education (NCATE). This affiliation means that any college or university seeking NCATE approval must, if the institution prepares science teachers for the middle grades, also meet the NSTA standards in order to receive NCATA approval for its preservice program. Not all institutions preparing teachers submit their preparation programs for NCATE approval but many do.

The NSTA standards advocate/require 36 semester hours of college science: 9 hours in biological or life science, 9 hours of physical science (physics and chemistry), and 9 hours of earth-space science, with the remaining nine hours to include electives from among the major science disciplines. (The NSTA recommended standards are shown in Figure 1 on the next page.)

Preservice Preparation of Middle School Science Teachers

The standards for science teacher preparation for middle school science advocated by the National Science Teachers Association provide for a stronger science content background than that normally found in most middle school teachers who enter middle school teaching via an elementary preservice program. They also advocate a special methods course focused on teaching science to middle school pupils, classroom observation and participation in middle school science classes, as well as student teaching for a semester or quarter in a middle school science assignment.

Recommended Standards for Middle/Junior High Science Teachers

Standard I.
Middle/Junior High Science Teacher Certification

Separate, specific middle/junior high school science teacher certification programs should be established. They should contain science content, methodology, field experiences, and professional orientation activities designed specifically for the middle/junior high school science teacher.

Standard II.a.
Science Content Preparation

A minimum of 36 semester hours of collegiate science instruction should be required of all preservice middle/junior high school science teachers. This coursework should include the major science disciplines of biology, earth science, and physical science, with at least 9 hours of biological or life science, 9 hours of physical science (physics and chemistry), and 9 hours of earth-space science. The remaining 9 hours would include electives from among the major science disciplines.

Standard II.b.
Support Content Preparation

The middle/junior high school science teacher should also have a minimum of 9 hours in mathematics and computer science instruction.

Standard III.a.
Science Teaching Methods Preparation

Middle/junior high school teachers should have a specific science teaching methods course.

Standard III.b.
Content of Science Teaching Methods Course

The methods course designed for middle/junior high school teachers should emphasize science curriculum development, appropriate instructional strategies and materials, techniques for evaluation of pupils and programs, and the application of recent research in the psychology and sociology of the early adolescent student as it relates to science instruction.

Standard IV.a.
Classroom Observation/Participation

Prospective middle/junior high school science teachers should have opportunities for classroom observation/participation in early adolescent science classes taught by competent teachers. Such experiences should be provided during each year of their preservice preparation program.

Standard IV.b.
Student Teaching/Internship

The culminating field experience for the preservice middle/junior high school science teacher should be an internship of one semester's or quarter's duration. There must be ample time and opportunity to plan and provide instruction for students in a middle/junior high school science classroom supervised by a competent science teacher.

Standard V.
College/University Science and Science Teaching Methods Faculty

The university/college faculty members selected to teach science and/or science teaching methods courses to preservice teachers should have professional preparation in these areas and be committed to the education of teachers of early adolescent children.

Standard VI.
Facilities, Equipment, and Materials

Preservice middle/junior high school science teachers should be instructed in science laboratories and educational facilities that include equipment, instructional materials, and library holdings that promote science learning and exemplify outstanding middle/ junior high school science programs.

Standard VII.
Professional Orientation

The middle/junior high school science teacher preparation program should provide experiences which will engender professional pride, dedication, and commitment to the early adolescent child and early adolescent instruction.

National Science Teachers Association, © 1983

Figure 1. NSTA Recommended Standards for the Preparation and Certification of Teachers of Science at the Middle/Junior High School Level

The field experiences (observation, participation, full-time student teaching) present no problems other than those of identifying middle school teachers who can serve as positive role models and who are willing to share their science classes with preservice students. The development of the science content sequence is less straightforward.

The NSTA standards call for the 36 semester hours to be divided among biological, physical, and earth-space sciences: 9 hours in each plus 9 hours of electives. This would imply that middle school teachers will be expected to adopt a general science approach to their teaching. However, when science textbooks designed for middle grades are surveyed, it is found that textbook publishers still adhere to the pattern established as a result of the National Science Foundation science curriculum improvement projects of the 1950s and 60s: one year of life science, one year of earth-space science, and one year of physical science. Textbook series in which a book at one grade level contains science information related to life, physical, and earth-space science all within the same book are difficult, if not impossible, to locate.

One way out of this dilemma is to purchase sets of textbooks, in varying numbers, rather than to adopt one text which is issued in quantities sufficient for each student to have a personal copy of the book. However, this also assumes that schools have a graded course of study for science in the middle schools that follows a general science approach at each grade level. Research would need to be done to determine how many middle schools have such a curriculum plan.

The infusion approach to science curriculum is another possible solution. Modules do exist that science teachers may incorporate into their curriculum to enrich and diversify it. This approach does not call for a drastic curriculum revision, only a modification.

These problems reflect the situation in public school science classrooms. It is necessary, also, to think about the college science courses available to prospective middle school teachers of science. Nine semester hours of study does not imply a great deal of depth in a particular area of science. What kinds of college science courses are available to prospective middle school science teachers? It seems likely that such students will elect to enroll in introductory courses, some of which may be designed to serve a population consisting primarily of nonscience majors. Such courses usually are survey courses and consist of large lecture sections. Frequently such courses do not have a laboratory associated with the lectures, nor is field work a common component.

Even if a middle school preservice student does elect science courses designed for science majors, will he/she be able to identify commonalities across science disciplines so that he/she is able to relate the material learned in life science to that learned in physical science and in earth-space science? Are college science courses presented in such a way that common themes cut across the various departments or are presented by all science areas? One would suspect that it is a rare institution in which this happens and, if such an institution exists, it should be identified and held up as a model to be emulated.

Can such a framework be developed so that it is acceptable to the scientists who teach the science content courses, to the science educators who work with pre- and in-service middle school teachers of science, and to the middle school teachers who will have to comprehend it and be able to apply it in their planning and teaching? What should it look like? How can communication among the stakeholders be facilitated?

The Importance of In-service Education

The development and implementation of preservice programs specifically designed to prepare teachers for the middle grades is an important task. It should not be neglected. However, even if such programs are begun or if they continue to be developed in greater numbers, this will not result in rapid change. Fiedler (1978) has provided several reasons:

> First, it would take at least two years following the adoption of a revised teacher preparation program and the accomplishment of all the tasks implicit in the proposal, debate, decision, and implementation of a new program to prepare this new kind of teacher effectively.
> Second, the number of newly prepared teachers that could be introduced into the system would be limited by the small turn-over in personnel in light of today's steady, static or declining student enrollment.
> Third, their limited numbers would be matched by their limited influence. Seniority and tenure apply in public schools, as in other settings. These newly prepared teachers, insignificant in number (compared to faculty as a whole) and tentative in their new roles, would, as has been suggested, have limited impact on the program in the middle school (p.323).

The National Middle School Association document also carries a section on in-service education:

> While pre-service middle grades teacher preparation provides a desirable and long-term approach to middle grades staffing, the realities of the current educational milieu require a more realistic emphasis upon in-service education for existing staff. Most of the teachers who will be teaching in middle grades ten years from now are already employed. Most of them received little or no specific preparation for the middle grades. Furthermore, even those teachers with adequate pre-service preparation need continuous retraining and renewal. (1986:12)

In-service activities will be needed to serve a variety of functions. Teachers with inadequate or out-of-date content backgrounds will need to update/upgrade their content knowledge. Teachers may need information about developmental growth characteristics of middle school students. They may also need to learn more about teaching/learning strategies that are appropriate for middle school classes. It is doubtful that such a program can be accomplished through a series of after school meetings; supplementary pay or release time will be needed to encourage teachers to participate. Time and money for such in-service activities are essential. In order for middle school science education to be effective, teachers need to know how students learn, factors that affect learning, and the importance of developing students' higher order thinking skills. Therefore, teachers need to have a background in learning theory and instructional design so that this information can be used in planning for the diverse capabilities of the middle school students. ". . . Teachers who neither understand the content nor the students they are working with can only be effective by chance . . ." (Thornburg, 1984:68)

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